

they also agglomerations of atmospheric dust, or does the atmosphere deposit in one place clay, another gravel, another rocks?

Modern physiography answers these queries of the Boston objector very easily. The rain combines with the wind to carry all fine particles down to the ocean as fast as they are formed anywhere in the atmosphere or on the land; it is only the coarser particles and the harder soils and rocks that, with the mould, remain in sheltered places to form the earth as we know it, and all these slowly disintegrate and go to the sea. We must acknowledge it as a truth that several inches, and in many places several feet, of soil are washed into the ocean in every century, and that the accumulated weight of the ocean bed is counterbalanced by a gradual rise of the continents.

Moreover, the well recognized permanent addition to our globe, due to showers and myriads of meteors, is probably equivalent to not less than 1 inch per century for the globe, equal to 4 inches per century for the dry land surface, and all this is carried to the bottom of the ocean. As the meteors are visible 100 miles above us, it follows that either an atmosphere exists at that elevation or else an encircling ring of meteoric satellites. From a meteorological point of view, therefore, this meteoric dust is also of importance. It is this latter dust that comes down to the lower atmosphere from the very greatest heights.

As only one copy of the *Western Minerva* is known to exist (see Mr. Fox's article in *Science*, above quoted), the present Editor has secured a manuscript copy of the remarks contained therein by Rafinesque on atmospheric dust. These are in the form of a letter addressed to Governor DeWitt Clinton,<sup>1</sup> of Albany, N. Y., and dated October 1, 1820. It is in continuation of his letter previously published in the *American Journal of Science*, and although it may have only a historical value, it will nevertheless interest many of our readers, and shows that Rafinesque was certainly quite as reasonable as his critics in the views advanced by him. The geological views expressed by him are certainly crude and erroneous, but there is a modicum of truth in his idea as to the importance of dust.

We reprint herewith Professor Rafinesque's second article as it originally appeared on pages 27-29 of the *Western Minerva*, correcting only a few slips that are evidently typographical errors:

DEAR SIR: I published in 1809 [evidently 1819—C. A.] some ideas upon this subject in the *American Journal of Science*. An anonymous reply to my remarks has since appeared in the same journal, which is calculated to mislead; and as I have not been able to avail myself of the same vehicle, in order to state more fully and explain the motives of my belief in the atmospheric spontaneous production of a great part of the dusty particles floating in the air, I take the liberty to address you some additional remarks on this subject, which, should my conjectures prove correct, will form an important link in the economy of nature.

The anonymous writer contends, with the generality of authors, that these dusty particles are altogether lifted by the winds and carried everywhere. I do not deny that the winds raise the terrestrial dust and often carry it to a distance; this happens whenever the ground is dry and the winds blow; but I assert that it is impossible that this terrestrial dust should be raised above the clouds or when the ground, being totally wet or frozen, *cannot afford any*. Yet, as a dust exists in the atmosphere as far as the clouds at all times, I venture to believe, with Virey, Patrin, Deluc, and other philosophers, that there must be another independent formation of dust in the atmosphere besides the scanty terrestrial supply wafted by the winds.

To prove this assertion, I need merely refer you to the observation of a very common meteoric phenomenon, which has seldom been noticed. Look at the clouds, toward sunrise or sunset principally, when the sun is concealed behind them, and an opening happens to take place through which the sun may shine obliquely. A pyramidal beam will immediately appear, similar to the luminous and dusty beam appearing in a room into which the sun shines obliquely. This common occurrence has received the vulgar name of *sunbeams*; but it is evident

that it is not a mere beam of light, since it is not so bright or dazzling as the bright sun rays, nor is it an optical reflection of the enlightened atmosphere, since it is brighter and not azure. It must, therefore, be a beam of atmospheric dust, and its identity with the beams produced by a hole in a screen or a window in a room is evident. If several openings exist among the clouds, many beams will be seen; and this phenomenon is sometimes visible without openings, when many clouds act as screens.

It remains to prove that this phenomenon happens when there can be no terrestrial dust in the air, else it would be contended that this dust rises (like balloons) to the clouds. Choose for your observation a short time after a long and heavy rain or snow, which must have precipitated all the terrestrial dust to the ground, and you will perceive the same sunbeams under similar circumstances. Whence it must follow that this beam of dust must have preexisted above the sphere of the storm and fallen since from above the clouds; and as it can not be admitted with plausibility that any great quantity of terrestrial dust can exist permanently above the clouds, so as to be able to form immediately such immense volumes of dusty beams, or rather to fill all the space between the ground and the clouds, I think it rational to presume that this atmospheric dust is continually formed or evolved in the atmosphere and falls down after the rain to fill the vacuum.

The insight given us by modern chemistry into the gaseous formations of solid substances, will be amply sufficient to account for this spontaneous formation. We know now that sulphurated arsenic and mercury, sulphur, muriate of ammonia, etc., can be formed by the sublimation of gases; that smoke, soot, manna, volcanic productions, meteorolites, earths, and even stones or metals, etc., may be spontaneously combined by a casual meeting or mixture of gaseous emanations. It is not, therefore, difficult to conceive how dusty particles may be formed in the great chemical laboratory of our atmosphere.

A singular instance of atmospheric formation has been recorded in the travels of La Pérouse. He saw, in a storm, on the east coast of Tartary, the actual formation of a number of slender threads, similar to spider webs. The numerous instances lately ascertained of earthy rains, containing many oxides, come still nearer to the point; they only differ from the common dust, by their tenuity, color, locality, and composition. They are local phenomena and productions, while the atmospheric dust is a permanent and universal phenomenon.

It is absurd to suppose that the atmospheric dust ought to have covered the earth with a coat or stratum 27 feet thick in 1800 years, as the anonymous writer wishes to suppose. Even if the average of dust falling in one century should be ascertained to be 6 inches, it must be remembered that the greatest proportion is precipitated by rains, diluted, and carried down the streams with the rain water; a small proportion alone is mixed with the soil and *increases its bulk*. It is only in hollows, caves, corners, pits, etc., that it may accumulate to a certain extent, and compression will greatly reduce it.

It is also absurd to ask whether this dust forms all the rocks and soils on the face of the earth. But it is reasonable to suppose that it contributes to a certain degree to their increase. Our soil is formed by the decomposition of rocks, the accumulation of vegetable and animal decayed substances mixed with this atmospheric dust.

That it may in some instances form or increase substances and stony strata or conglomerations can not be denied, since this effect takes place under our eyes in cisterns and reservoirs of rain water. The earthy and dusty particles conveyed into them by the water are gradually deposited, forming concretions and stones. This is very evident in the old cisterns of the east, which have held rain water during a long period of time.

Everything, therefore, seems to indicate that there is an extensive and permanent formation (and fall) of dust in the atmosphere; that it contributes to form our soils, our alluvions, and some stones; to fill the fissures and hollows of rocks and lavas, preparing them for vegetation; and that in former times, when many of our substrata were formed, it may have been more abundant, contributing to the formation of some of those strata.

This may appear paradoxical to some persons slightly acquainted with geological and meteorological phenomena, but not unreasonable to those who observe with care. I have ventured to announce in my lectures that another formation must be added to our present geological formations, the atmospheric or meteoric formation, to which must be referred all those singular geological anomalies which puzzle so much the systematic writers, when they find extraneous stones, soils, metals, and other substances mixed or superincumbent over late or newer formations. It may perhaps in time be found necessary to ascribe to meteoric formation those extensive substrata and upper strata of sand and gravel, which can not properly be deemed alluvial nor volcanic. When our rocks were formed under water by deposition, many of their principles must have originated in the briny ocean, but some may have been derived from the atmosphere.

#### LIGHTNING FROM A CLOUDNESS SKY.

Mr. J. N. Weed, of Newburg, New York, writes as follows: On Friday evening last (August 3), myself and five others were on

<sup>1</sup> Governor Clinton was at this time President of the Literary and Philosophical Society of Albany, and numerous scientific papers published in the *American Journal of Science* were originally addressed to him and read before that Society previous to their publication.

an elevation commanding a perfect horizon in the east, observing the stars with a telescope, and awaiting the rising of the new comet, Brooks. At 7:30 p. m. there was a light wind in this locality from the northwest, mere breathings. At about 9 p. m. there came a sudden gust of wind, lasting but the fractional part of a minute, and then, some minutes later succeeded by another gust of more force. After this they came more frequently, and soon developed into a cold, gusty, northeast wind, which lasted with variable force until 1 a. m., when I retired. At that hour the wind was strong but more to the north. Our horizon in the northeast quadrant is low. In the southeast, limited by mountain crests from four to seven miles distant, and ranging from one thousand to sixteen hundred feet high. Beyond this horizon are a succession of other mountains hidden from our view, with deep valleys between, including the valley of the Hudson River. The night was cloudless until the wind came.

Soon after this a few cloudlets of stratus formed near the north end of the mountains, say east-northeast, near the horizon, but disappeared before the appearance of the phenomenon I am about to mention.

At the moment of the rising of Fomalhaut above the mountains southeast, we noticed a gleam of lightning, of rather delicate type, just to the left of the star, and back of the mountains. The conditions were such that we could hardly believe that it was lightning, but it continued and increased, waxing and waning until we discontinued observations at 1 a. m. It seemed to me that it changed intensity with the wind. The lightning occurred at frequent intervals all along the horizon from the point of origin to near the east point, and was undoubtedly true lightning.

This is the first time I ever saw lightning in a cloudless sky, and it occurred to me that it might be of interest to the Weather Bureau to question their observers about it, as such phenomena are rare.

My first impression was that it was the reflection from a distant thunderstorm, as the lightning seemed always beyond the mountains and the place of origin below the crest line. On inquiry of some friends who were at Hemstead, L. I., that evening, they informed me that the night there was cloudless, and that at one time lightning occurred, as they then thought, but later concluded it was produced by a falling meteor of the August stream, many of which were visible that night there, as well as here. This information seems to exclude the thunderstorm theory. It seemed to me possible that the cold, gusty wind currents, falling at a steep gradient, as shown by the gusty type of the wind, might exchange electricities with the warmer surface air forced upward, and thus explain the phenomenon. The character of the topography would seem favorable, under such conditions, to the formation of convection currents with steep gradients.

With regard to the above, the Editor can only say that the daily weather map for 8 p. m., August 3, gives no indication of conditions favorable to lightning in the neighborhood of Newburg on the Hudson. In fact, the map shows that New England and eastern New York were in the midst of an area of high pressure and cloudless skies, and the cool, northerly winds had rapidly extended southward over this region. In general, as we have often had occasion to say, cloudless skies and dry air mean a general descending tendency in the atmosphere. The cold air that streamed down the Hudson River Valley was but one incident in the general character of the high area. Inasmuch as the sky was clear for 100 miles east of Newburg, we think there is no reason to assume a distant thunderstorm or even real lightning flashes between the earth and the sky, and we therefore incline to believe that Mr. Weed, like his correspondent at Hempstead, L. I., must have observed the flashes produced by distant meteors descending, perhaps nearly vertically, through the air toward the earth. Still, to a careful observer, the lightning flash and the meteor flash ordinarily present very different appearances, and we should be glad to receive some better explanation from those living east of the Hudson who may have seen the same phenomenon.

On Tuesday, August 7, about 5 p. m., according to a news despatch from Richmond, Va., lightning from an apparently clear sky, without warning, struck Mr. W. R. White and a colored farm hand near Coldharbor, Hanover County, while both were working in the open field.

The weather map gives no indication of any thunderstorm or rain in this neighborhood at that time; an area of high pressure prevailed, with very hot atmosphere near the ground. During the subsequent night it was cloudless throughout this

region; a cool northwesterly wind sprang up. The circumstances are parallel to those attending the small lightning flashes seen at Newburg, except that the latter occurred at night-time. In both cases a cool breeze succeeded to a hot day, whence we infer that a vertical circulation of air was in progress. Ordinarily we think of the lightning that attends a thunderstorm as being in some way the result of the formation of cloud and rain or hail, but the frequent reports of lightning from a perfectly clear sky seem to suggest that the ascent and descent of the currents of air is the important feature in both cases.

#### WEATHER BUREAU STATION ON TURKS ISLAND.

Through the kindness of the local authorities, the Weather Bureau has opened a station at Grand Turk, Turks Island, W. I. (latitude,  $21^{\circ} 20' N.$ ; longitude,  $71^{\circ} 0' W.$ ; height of barometer above sea level, 11.3 feet). The station is located at the cable hut and the observations are made by Mr. O. Crewe-Read, who is not only station agent for the Weather Bureau but also operator for the cable company. His weather report will now be published regularly in the Royal Standard newspaper at that place and replaces the weather report hitherto published as made up by the messenger at the public buildings. When so ordered from headquarters at Washington or Havana, Mr. Crewe-Read will post on the bulletin board at the post office, advisory messages relative to hurricanes in the vicinity, and if one is to approach too near the island he will order the hurricane warning displayed on the flagstaff of Messrs. Frith, Brothers, so that the public may have ample warning of the approach of a dangerous storm.

The arrangements above mentioned were made under the immediate supervision of Dr. H. A. Frankenfield, Forecast Official, who visited the island for this purpose in June.

#### WELLS AND STORMS.

A correspondent says:

Why is it that in dozens of our bored wells the water just before a storm becomes riley, or partly muddy? From twelve to twenty-four hours before a storm my well becomes muddy and stays so."

As we know nothing about the location of these wells or the character of the storms with which the phenomenon occurs, we can only suggest a possible explanation. Extensive storms occur in the midst of areas of low pressure. When the barometric pressure is diminishing the air imprisoned within the soil can more easily push its way outward. Wells are but holes that open the way into the lower strata, and give the air and water contained therein an easier mode of egress. Every area of low barometer that passes near the well facilitates the escape of gas, and even of water, so that the well should stand higher when low pressures prevail. The bubbling up of the air through the water would undoubtedly make it riley, and, especially so if there be a deposit of fine mud and decaying vegetable matter at the bottom of the well. The trouble can be partly remedied in "dug" wells by placing one or two broad flat stones in a slightly inclined position at the bottom of the well, so that rising bubbles and muddy water are turned off to one side. But for bored wells, whose sides are cased with iron piping, we know of no remedy. Natural springs often flow more freely when the air pressure diminishes.

#### THE FREQUENCY AND EXTENT OF DESTRUCTIVE HAIL.

A newspaper paragraph states that a destructive, and in fact terrific hailstorm, occurred on July 30-31, in the valley of the Verde River, Ariz., and, especially between Pima and